# Using Ontologies and Soft Systems Methodology to Provide Multi-user Support in Problem Structuring

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## Abstract

*Decision support systems (DSS) are aimed at helping decision makers in devising appropriate solutions to business problems while negotiation support systems (NSS) are aimed at assisting stakeholders in reaching mutually satisfactory decisions. The successful use of these systems involves a combination of human ability and computer support. An implicit assumption underlying their use is that the business problems for which they are deployed have been carefully defined by the stakeholders prior to their use. This includes, in particular, understanding of the problem variables and their possible impact on the decision outcomes and knowing which information is necessary for supporting it. However, this assumption might not hold in the modern business environment. This is due to the increasing complexity and rate of change of the environment, the geographical and temporal dispersion of modern organizations, and the diversity and quantity of information sources that is available. In this paper we propose the idea of extending the scope of these systems to include a step preceding the solution process: problem framing. We claim that new technologies such as Web 2.0 provide novel opportunities to add this facility to DSS and NSS. To achieve this, we propose a novel approach combining domain and task ontologies. The task ontology we propose employs concepts from soft systems methodology. Specifically, we suggest that a stakeholder can use the ontologies to understand the problem, frame the issue, and identify the information required for the task. The ontologies can support accessing the information sources when the system is being used by stakeholders.*

## 1. Introduction

The value of IT-based systems for various decision tasks in organizations has been recognized for a while. This includes, in particular, decision support systems (DSS) and negotiation support systems (NSS). The application of such systems is based on certain assumptions. These assumptions include, in particular, that decision makers and stakeholders understand the problem domain and agree on their views of these domains and that stakeholders are aware of the information resources available to them and needed to support them in performing their tasks. However, often these assumptions might not hold true, and their validity is challenged by the increasing complexity of the modern business environment, by the very fast rate of changes in this environment, and by the wide dispersion of modern organizations.

The rapid evolution of communication technologies, and more particularly the broad adoption of what is now called Web 2.0, inside and outside organizations, provides an opportunity to rethink our approaches to decision-making and negotiation support. In particular, these new technologies can be deployed to overcome the challenges mentioned above.

Moreover, as mentioned by French et al. [14] "more and more management interactions in organizations are being conducted via the web", mainly due to the fact that face-to-face meetings are difficult and costly to arrange in organizations that are more and more geographically and temporally dispersed. Relevant information is also scattered and shared through the whole environment (internal datacenters, electronic marketplaces, global fulfillment platforms, etc.). Thus, not only the technology is already heavily intertwined in the processes underlying decision making and negotiation but also information was never so dispersed.

This led us to identify four kinds of issues impacting stakeholders using these systems: (1) domain understanding, (2) problem formulation, (3) specification of issues and options and (4) information identification. In this research-in-progress, we propose to address these four areas using an application ontology based on soft systems methodology (SSM) and domain ontologies, which are formal representations of concepts and their relations

within a domain. This novel approach, combining well-established concepts and methods, allows us to provide an innovative response to these issues.

The rest of the paper will present, the issues in negotiation support that are arising from the changes in the environment. Then, we show how ontologies can solve the first issue, the shared domain understanding. We then use these ontologies and a problem structuring method (PSM) to elicit the problem formulation. Finally, we present how the combination of the ontologies and the PSM can effectively support users in specifying the issues and options. We then conclude by presenting some further work that we will carry out in order to validate our overall approach.

## 2. Supporting negotiations

Negotiation is a "decentralized decision-making process used to search for and arrive at an agreement that satisfies the requirements of two or more parties in the presence of limited common knowledge and conflicting preferences" [4]. The key assumption regarding negotiation is that, in order to reach an agreement, it should achieve a consensus between the parties regarding a specific alternative [25].

### 2.1. Negotiation support

The generic negotiation process is characterized by a five-phase model [4]: (1) planning, (2) agenda setting and exploring the field, (3) exchanging offers and arguments, (4) reaching agreement and (5) concluding the negotiation. Due to the increased complexity of the environment and the increasing effort and time invested in negotiations within and among organizations [22], NSS have been designed in order to support all five negotiation phases. Jelassi and Foroughi [24] identified five factors impacting the structuring of negotiations, and believed to be relevant to NSS design: (1) separate the people from the problem, (2) provide communication between negotiators, (3) help negotiators identify their real interests, (4) generate options for mutual gain, and (5) use objective criteria.

This led to the definition of NSS: "Negotiation support systems are designed to help and advise negotiators during the various phases of the negotiation process; they are used to structure and analyze the negotiation case, elicit preferences and use them to construct a utility function, determine feasible and efficient alternatives, set negotiation tactics, visualize different aspects of the problem and the process, and facilitate communication" [4].

During the past few years, a new kind of NSS has emerged, the e-negotiation system (ENS). As seen before, they are NSS that are built on the new opportunities offered by the web technologies. Following this evolution, in a previous research, we designed and developed an ENS based on an automated negotiation agent [16]. Some of our results showed the importance of supporting users in sharing a common understanding of the problem [15].

### 2.2. Negotiation problems

The problem definition and formulation take place during the first phase of the negotiation process. Negotiators "formulate their representation of the negotiation problem including the specification of issues and options" [4].

However, Braun et al. [4] note that "real-life negotiation problems are typically ill-defined, information is not equally distributed among the participants, the participants have only partial knowledge about their counterparts and communication is often ambiguous or imprecise". Moreover, current changes in the environment also imply a transition from tame to more wicked negotiation problems, partly due to their complex interdependences.

Examples of wicked issues are found in areas such as global climate change, nuclear energy, genetically modified foods, sustainable development, etc. Typical issues are not-in-my-backyard projects involving many actors with very different values and priorities. These wicked issues imply that negotiations are characterized by (1) involving "many stakeholders with different values and priorities", (2) having complex and tangled roots, (3) its being "difficult to come to grips with and changes with every attempt to address it", (4) having no precedent and (5) having no "right" answer [6]. On the other hand, "tame problems are characterized by clear definitions of the problems which do not change over time" [1], even if they can be complex and difficult, like, for example, landing men on the moon or finding the source of the E. coli food contamination outbreak in Europe.

Still, as reported by Belton et al. [2] and supported by many researchers, "far more attention must be paid to problem structuring" in NSS, and subsequently, in ENS even if problem structuring is considered by French et al. [14] as "an art rather than a science".

This worsens with ENS as there are no opportunities to share a common understanding of the problem domain outside of the ENS itself due to the geographical and temporal dispersion of the parties. This raises the issue of integrating a generic support to frame ill-defined wicked problems in the context of ENS, supporting conflicting objectives arising from different world views.

Given the characteristics of negotiations and wicked problems, the expected functionalities of NSS and more particularly ENS, along with our previous findings, we identified four issues that should be addressed by ENS. These issues, the functionalities that they are impacting and their possible causes are presented in Table 1.

In order to address these issues, we study the use of a combination of problem structuring methods (PSM) and ontologies. The first one supports a common understanding of the root cause on which the negotiation depends and the second one supports a common understanding of the concepts and their relations, describing the root cause itself.

Table 1: **Main issues affecting ENS**

| **Issue area** | **Impacted ENS functionalities** | **Possible causes** |
|---|---|---|
| Domain understanding | Understand the problem [15]<br>Visualize different aspects of the problem [4] | Rapid changes happening in the domain<br>Non-domain experts involved in the process |
| Problem formulation | Separate the people from the problem [24]<br>Structure and analyze the negotiation case [4] | Dispersion of the actors<br>Users from various areas of expertise<br>Problems are ill-defined |
| Specification of issues and options | Help negotiators identify their real interests [24] | Nature of wicked problems<br>Users have various world views |
| Information identification | Use objective criteria [24]<br>Assess and present arguments [4] | Dispersion of the information<br>Quantity of information available |

# 3. Ontologies supporting shared understanding of problem domain

Ontologies, which are descriptions of concepts and their relationships in a given domain, are present in some form in most organizations. We found implicit and more or less formal ontologies in most enterprise resources planning, consumer relations management or human resources management systems. Formalized ontologies are found in knowledge management systems and explicit ontologies are used in quality management [27] or security certifications. Enterprise architecture (EA) [28], in attempting to get a holistic view of the enterprise, led indirectly to the creation of enterprise-wide ontologies. The enterprise ontology is also a systematic attempt to create a collection of terms and definitions relevant to business enterprises [35].

Ontologies are also used to provide meaning to data. Kim et al. [26] studied various tag ontologies, which are ontologies that describe tags, as used in user-generated and distributed classification systems, and allow for relationships between tags to be described, and they proposed a semantic model for tagging data. This will support organizations and their collaborators in increasing the value of their information repositories. Furthermore, there are more and more research findings in AI that support automated information extraction and sense-making from unstructured material based on ontologies [34].

## 3.1. Operations on ontologies

To enhance our approach of using ontologies in negotiation support, we build on the idea of the ontology library and the combination of these ontologies [21]. Each ontology being a conceptualization of a given domain, combining multiple ontologies of related domains will enable us to create a web of knowledge covering the whole problem domain.

Ontologies can be combined using multiple operations and properties. The most common operations are: merging (creation of a new ontology, based on existing ones, that contains all the knowledge of the merged ontologies), mapping (creation of a translation between statements in multiple ontologies), alignment (mapping multiple ontologies to support their interoperability in a way that all statements are present in all ontologies), refinement (mapping from concepts in an ontology to higher-level concepts in another ontology in order to define a hierarchy between them), extension (mapping multiple ontologies in order to widen the domain covered by the ontology) and specialization (enrichment by extension and refinement). Ontologies also have an inheritance property. This means that one ontology can inherit all or some concepts and relations from another ontology, given that there are some mappings between them. It introduces partial ordering between ontologies.

To give some examples from the literature: Opdahl and Berio [32] are in the process of specifying a unified enterprise modeling language (UEML) in “an ongoing effort to develop an intermediate language for modeling enterprises and related domains, such as information systems”. Gruber [17] developed Ontolingua as an interchange format to define ontologies that are portable over representation systems. There is also a significant amount of research that addresses ontology matching and schema matching at different levels, mainly based on various

heuristics [13]. Guarino and Welty [19] provide OntoClean, a "methodology for validating the ontological adequacy and logical consistency of taxonomic relationships".

## 3.2. Expressing the problem domain using ontologies

We suggest representing all the problem knowledge through the extension, refinement and specialization of various ontologies providing conceptualizations of specific domains or parts of them. In our understanding a domain is a specific subject area or area of knowledge. This construction can support the exploration of problem-related knowledge by browsing the various concepts and their relations. Moreover, reaching the boundary of the problem knowledge, it is possible to extend it by linking other ontologies or by specializing the current ontologies. For example, if we face a negotiation consisting of reducing the CO2 emissions of a fleet of vehicles, we might have concepts such as consumption, mileage and emission (the last is linked to the first two). If for some reasons we need to understand the consumption more precisely, we can then refine the consumption concept with concepts such as tire grip, air resistance and weight.

Table 2: **Some relevant ontologies and their concepts in the context of a collective agreement negotiation**

| **Ontology** | **Concepts** |
|---|---|
| Employee | Status (permanent or non-permanent), Contract, Seniority, ... |
| Company | Shareholder, Stakeholder, Employee, Profit, Productivity, Product, Customer... |
| Union | Union Security, Election, Delegation, Representation, Member, ... |
| Collective agreement | Rights of Parties, Organization of Work, Labor Relations, Education, Training and Development, Conditions of Work |
| Conditions of Work | Work Schedule, Overtime, Job Security and Termination, Pay, Leave and Vacations, Benefits, Seniority |

In order to illustrate the representation of the problem domain with ontologies, we will use an example based on the negotiation of a new collective agreement between a postal workers' union and their employer. This example has the characteristics of a wicked and hard negotiation problem and represents a typical use of an NSS or an ENS–examples on this subject have already been used in the literature [5], [36]. We present some ontologies that are relevant in this context with their associated concepts in Table 2. Most of these concepts are taken from Human Resources and Skills Development Canada [23].

These ontologies, as we suggested before, could be found—in some form and to varying degrees of formalization—in the human resources management system, in the by-laws of the union, in the federal policy on collective agreement or in the enterprise resources planning (ERP) system. Using these formal concepts in the planning process of a negotiation will support the parties in sharing a common understanding about these concepts. Indeed, if the parties are arguing about employee status, they all know that it relates to their permanent or non-permanent work contract.

Moreover, these ontologies can also be used to provide context or meaning to the associated data. Using Courtney's [12] definition, "data are raw facts or simple observations about the state of the world; information is data in some context, or with some kind of human interpretation applied; and knowledge is information with guidance for action". Thus the resulting information can then be identified by non-domain experts, using the combination of multiple ontologies. A legal adviser would be able to identify all patents used by a given technology without knowing the details of the technology, using a legal ontology connected to the product ontology. This could allow stakeholders to identify and retrieve information outside their knowledge field through the inheritance property of the ontologies. In our example, identifying the different employee status as an area of divergence in the negotiation process, the users can use the ontology to identify all employees having a disputed employee status, in order to produce some statistics to support their argumentation.

## 3.3. Visualization of the problem domain ontology

"Ontologies are usually provided to users as graphical depictions of concepts and relationships because visual information is extremely helpful for people who need to learn about a domain" [3]. Therefore, a visual representation of the problem knowledge in the form of ontologies will improve the stakeholders' performance and support them in learning and understanding the problem domain. In order to represent the whole problem domain, we apply merging, mapping and refining transformations to these ontologies. The result of these transformations is a web of concepts and their relations covering the whole problem domain: the domain ontology. An extract based on our example is presented in Figure 1.

The domain ontology represents all concepts and their relationships that are needed in order to improve the domain understanding of the parties. It is also

useful in order to introduce non-domain experts such as negotiation specialists, decision analysts or policy makers in the negotiation process. However, this representation is a generic view of the domain. It does not represent the specific world views of the parties about the negotiation issue. For example, the employee status could be viewed as a flexibility tool by the management, as a discrimination by the union and as a security by the permanent employees. This various world views will have an impact on the planning process of the negotiation, as they will highlight the areas of disagreement between the parties. In order to support the various world views of the parties during the elicitation of the negotiation issue, we will use problem structuring methods.

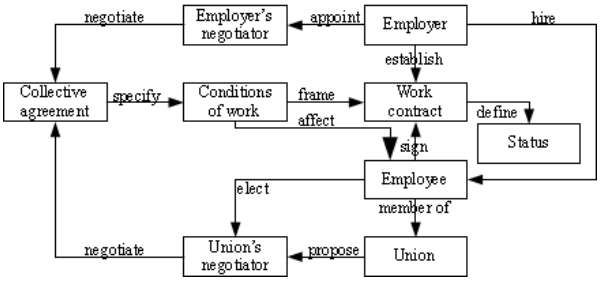


Figure 1: **Extract of the visual representation of the problem domain ontology**

## 4. Using problem structuring methods to elicit negotiation problems

Problem structuring methods (PSM) are issued from soft operational research (OR) in the UK. They "provide a more radical response to the poor fit of the traditional OR approach for wicked problems—a response based on the characteristics of swamp conditions rather than on a preexisting investment in high-tech solution methods" [33]. Moreover, they are "appropriate for situations characterized by multiple actors, differing perspectives, partially conflicting interests, significant intangibles and perplexing uncertainties" [33].

The PSM family comprises various methods, the most used being: strategic options development and analysis (SODA) which uses cognitive mapping to support general problem identification; soft systems methodology (SSM) which supports system redesign in building conceptual models supporting various world views; and strategic choice approach (SCA) which manages uncertainty in strategic planning situations [30].

### 4.1. Soft systems methodology

In our context, we choose to use SSM as it was developed to cope with a "situation in which the people in a problem situation perceive and interpret the world in their own ways and make judgments about it using standards and values which may not be shared by others" [11]. Moreover, SSM "assumes that different individuals and groups, being ultimately autonomous, will make different evaluations leading to different actions" [8], which fits in with our ENS context.

SSM was first developed in the 1980 by Checkland [7] in order to overcome the "failure of systems engineering to cope with anything other than well-structured problem situations". The methodology is based on seven steps: (1) entering the problem situation, (2) expressing the problem situation, (3) formulating root definitions of relevant systems, (4) building Conceptual Models of Human Activity Systems, (5) comparing the models with the real world, (6) defining changes that are desirable and feasible, and (7) taking action to improve the real world situation [7]. This approach is summarized by Checkland & Poulter [10] as "an action-oriented process of inquiry into problematical situations in the everyday world; users learn their way from finding out about the situation to defining/taking action to improve it. The learning emerges via an organized process in which the real situation is explored, using as intellectual devices—which serve to provide structure to discussion—models of purposeful activity built to encapsulate pure, stated worldviews".

"to formulate some models which it is hoped will be relevant to the real-world situation, and use them by setting them against perceptions of the real world in a process of comparison", the main point being the accommodation of different world views, which support the different users in having "their own interests and perspectives that lead them to pursue different objectives and to identify different factors as relevant" [33].

In a study of the use of SSM in practice, Mingers & Taylor [31] found that one of its strengths is its "practical usability in a wide range of situations by people without technical backgrounds". They also figured that the main reason to use SSM in practice was to develop understanding in the context of general problem solving (understanding complex situations, problem clarification) and knowledge acquisition. This study also points out that one of the main benefits of using SSM is its ability to "generate understanding of other people's perceptions and perspectives".

In an ENS context, we will restrict the use of SSM in developing the understanding of the issue, which concretely sets the emphasis on the first four steps of the methodology. Indeed, SSM having been developed to address wicked or ill-defined problems, the methodology covers both problem identification and problem resolution, the resolution phase being oriented

toward reducing the gap between one party's world representation and the real-world itself. In the case of a negotiation, parties have to agree on a world representation that supports their different world views. And finally, it is that negotiated world representation that will need to be applied to the real world, this last action falling outside of the negotiation process.

In order to illustrate this distinction we could take the negotiation over the fixing of national boundaries after a war. Each party has its own world representation about the border positioning. The negotiation process will end up with an agreed delineation between the territories. This world representation still does not represent the physical borders; it will not prevent anyone from "crossing" the new border. It has first to be applied to the real world in order to become effective. However, the real-world implementation of the border is a direct consequence of the negotiation process, but it is a distinct process.

## 4.2. Using SSM with ontologies

SSM not requiring the use of specific formalization of the concepts in order to create root definitions and build conceptual models, nothing restricts us in using our previously defined domain ontology to support the representation of the problem. Thus, using ontologies during the problem elicitation process will guarantee a common understanding of the problem domain by geographically and temporally dispersed parties who have different world views. At this point, it will not act on agreeing on a common world view but rather on sharing a common understanding of each of the parties' world views.

**4.2.1. Finding out.** The first two steps of the SSM are dedicated at finding out about the situation, the goal being to define a generic overview of the situation that can be shared by all parties. In our example, this is the willingness to sign a new collective agreement. This overview is then refined by three analyses, that are based on the actors' system, the social system and the political system. The analyses are named Analysis One, Two and Three.

Analysis One identifies the occupiers of the roles "client(s)" (who cause(s) the intervention to take place), "would-be problem solver(s)" (who conduct the study) and "problem owners" (the clients and people with an interest in the situation or who are impacted by changes in the situation) [29]. Analysis Two analyzes the social system, identifying the social "roles" that are significant in the situation, the "norms" of behavior that are expected and the "values" used to assess the performance of the roles. This analysis focuses on the cultural aspects of the situation. Finally Analysis Three focuses on the political system, identifying the sources of power and the way it is expressed. The results of these three analyses are often represented by a rich picture, which is an "account of the situation as a picture" [10]. We present such a representation in Figure 2.

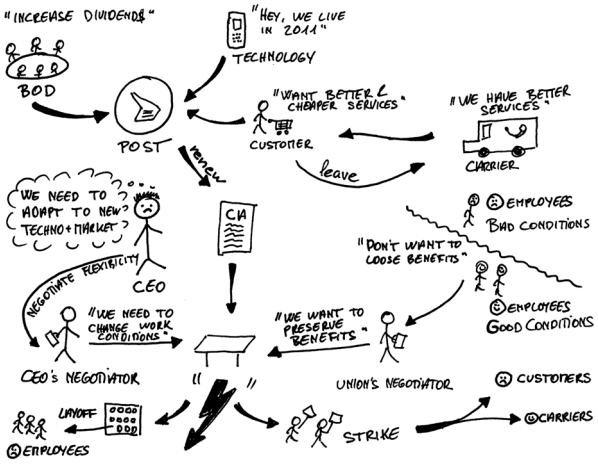


Figure 2: **Rich picture of the situation**

**4.2.2. Conceptualizing.** Having a rich picture of the situation, the following phase will deal with the formulation of root definitions and the building of conceptual models. It can be done in a sequence of three activities: (1) formulate root definition, (2) assemble minimum necessary activities, and (3) structure activities into a conceptual model [7].

A root definition of a system for carrying out purposeful activity is a synthetic description of a system considered relevant in achieving the negotiation, in the context of a specific world view. In order to formulate root definitions, Checkland created the CATWOE approach [9], presented in Table 3.

Table 3: **The CATWOE approach [9]**

| | | |
|---|---|---|
| **C** | Customer | Who would be victims/beneficiaries of the purposeful activity? |
| **A** | Actors | Who would do the activities? |
| **T** | Transformation process | What is the purposeful activity expressed as: input → T → output? |
| **W** | Weltanschauung | What view of the world makes this definition meaningful? |
| **O** | Owner | Who could stop this activity? |
| **E** | Environmental constraints | What constraints in its environment does this system take as given? |

The root definitions are created using all or most elements resulting from CATWOE, using "the PQR formula: do P, by Q, in order to help achieve R, where PQR answer the questions: What?, How? And Why?" [10]. Each root definition being tied to a specific world

view (W), we need to formulate enough root definitions to represent all parties' views.

In Table 4 we present two different world views of the collective agreement issue. We then express them as root definitions in Table 5.

Table 4: **Two different world views**

| | | |
|---|---|---|
| **C** | Employee, Shareholder, Stakeholder | |
| **A** | Union's negotiators and employer's negotiators | |
| **T** | Collective agreement → Collective agreement renewed by concluding the negotiation | Social benefits → social benefits preserved by concluding the negotiation |
| **W** | This adaptation to changing market conditions, increased competition and new technological environment is vital to the profitability of the company. | The long tradition of social benefits of the ex public enterprise should not be sacrificed just to increase profitability. |
| **O** | Employees, employer | |
| **E** | Governmental policies on collective agreement, collective layoffs and strike [20]; wide unionization of employees; increased competition by privately owned carriers | |

Table 5: **Two examples of root definitions**

| | |
|---|---|
| A system run by appointed negotiators to renew a collective agreement between a postal union and a postal service, taking into account the necessary adaptation to new market conditions and techno-logical environment | A system run by appointed negotiators to guarantee the social benefits of widely unionized postal workers, protecting them from strategies to increase profitability to their detriment |

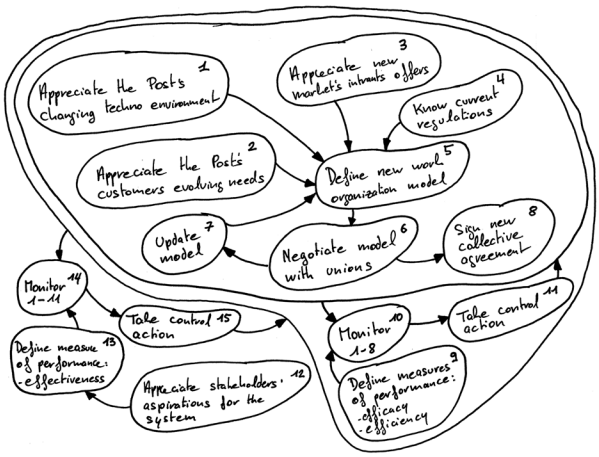


Figure 3: **A conceptual model of the negotiation of work organization in the renewal of a collective agreement**

The second part of the conceptualization consists in building conceptual models of the activities that should be part of the system defined by a root definition, each activity being connected to another one based on their logical dependency. Checkland makes two prescriptions concerning the creation of the models. The first is to limit the number of activities to 7±2 in order to accommodate our limited cognitive capabilities [9]. The second consists in adding a monitoring and control system to the model. This system will support our considerations concerning the "effectiveness" of the system (doing the right thing), its "efficacy" (does the means work) and "efficiency" (with the right amount of resources). Such a model is represented in Figure 3.

## 5. A problem representation based on ontologies and CATWOE

Having a problem representation and a problem domain ontology, we need one more step in order to cover all issue areas presented in Section 2. We have seen before that ontologies support various types of operations and have applied these operations to various domain ontologies in order to build the problem domain ontology. Continuing in this direction, we will specialize both the domain ontology and the task ontology in order to form an application ontology, which could then be used by the ENS as presented in Figure 4.

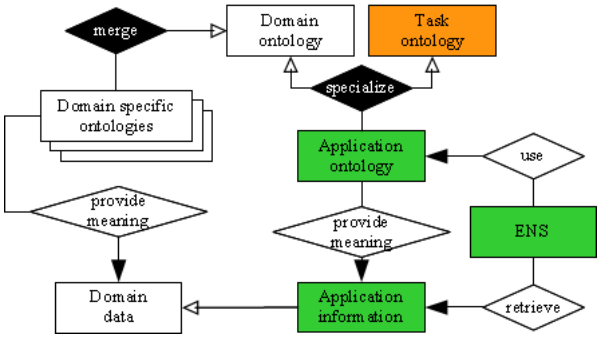


Figure 4: **Model of an ENS using multiple ontologies**

### 5.1. Task ontology

To the best of our knowledge, there is no generic problem representation ontology developed or published in the context of negotiation. Therefore, we suggest using the CATWOE root definition method as a basis for creating the ontology. As we have seen in Section 4, the SSM use the CATWOE approach to support the elicitation of the root definition of the negotiation. This elicitation results in problem formulations based on various world views. Thus,

using a task ontology [18, 21] based on CATWOE to represent the problem is a direct consequence of using SSM to elicit the problem representation.

This ontology, depicted in Figure 5, represents the generic (not problem-specific) problem representation concepts and vocabularies needed to support the negotiation activity.

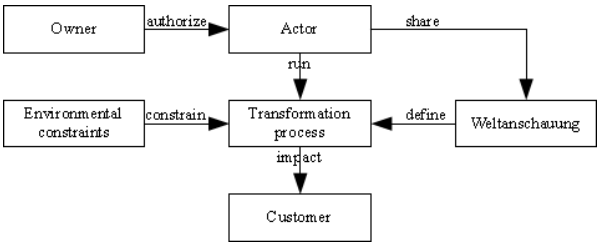


Figure 5: **Concepts constituting the application ontology**

## 5.2. Application ontology

Finally, the application ontology is a specialization of both the domain ontology and the task ontology. It represents the knowledge required in order to carry on the negotiation. The specialization process is based on the relationships expressed during the third stage of the SSM conducted in Section 4.2. Most concepts of the domain ontology are instances of the task ontology:

```
POSTAL WORKER UNION is an ACTOR
POSTAL WORKER is a CUSTOMER
```

Moreover, being an ontological representation of the negotiation problem, this ontology now supports a shared understanding of the negotiation issue. It also allows non-domain specialists to understand the problem domain in order to better grasp the issues at stake during the negotiation process.

## 5.3. Application ontology supporting ENS

In the previous sections we have shown how to construct an application ontology supporting an ENS. This ontology overcomes the issues previously identified in Section 2. Table 6 repeats these issues and shows how they are addressed by our approach.

We have shown that, by using a combination of SSM and ontologies, we are able to build an application ontology being a structured and formal representation of a negotiation issue. We also proposed to use CATWOE as the basis for the task ontology. The advantages of using this method to support the formulation of the issues at stake is that it is mostly based on techniques and knowledge that are already available in most organizations, without impacting the choice of the ENS itself.

The integration of the application ontology with the ENS goes beyond the scope of this paper. For now, these two processes can be done independently but should be run in sequence as the construction of the application ontology is required as part of the planning process, and is used to inform the ENS on the issues and options at hand. The independence of these processes is such that they can be run by different actors, the comprehension of the problem formulation being guaranteed by the use of ontologies. Thus we can delegate the creation of the application ontology to decision analysts and the negotiation itself to negotiation specialists who do not need to have an extended knowledge of the problem domain, the latter being provided by the ontology.

Table 6: **Summary of issues affecting ENS and the ontologies that address them**

| **Issue area** | **Addressed by** |
|---|---|
| Domain understanding | Domain ontology |
| Problem formulation | Domain & Task ontology |
| Specification of issues and options | Application ontology |
| Information identification | Application ontology |

In conclusion, the application ontology, including various world views of the issue at stake, can be used not only to represent the problem, but also to identify the specific elements that should be discussed during the negotiation process, more specifically during the second phase of agenda setting and exploration of the field. The analysis of the application ontology will support the parties in identifying the concepts subject to disagreement. So, in our example, the flexibility of the work hours is a depreciation of the work conditions from an employee point of view and is seen as an instrument to increase productivity from a management point of view. Using the same concept of flexibility of the work hours in both representations will support the preparation of the negotiation agenda.

Moreover, due to their inheritance property, ontologies enables us to browse the application ontology in order to discover new relations or dependencies during the planning phase of the negotiation process. It also provides us with an efficient way to discover and retrieve the needed information, given that these ontologies are providing the meaning to the underlying data as shown in Figure 4. Thereby, the ontology acts as a gateway toward the information that is required in order to inform the negotiation process, as seen in Section 3.

# 6. Exploring the Ideas

We have proposed a new approach, combining a domain ontology and a task ontology based on

CATWOE in order to support issue framing and information sources identification prior to the use of a computer support system in a negotiation context. However, although we have laid the theoretical foundations of our approach, it needs further work in order to validate our ideas. We will follow a twofold research agenda. First, empirical work will address the following research questions: (1) can an application ontology support a user in framing a problem, (2) can an application ontology support a user in identifying relevant information sources related to a framed issue, and (3) can an application ontology assist a user in retrieving problem-domain information during the decision or negotiation process. The second aspect of the research will be devoted to the design and evaluation of a prototype supporting our approach.

As this is research in progress, we will give an overview of the first two experiments to be conducted, followed by a presentation of the remaining research questions to be addressed by empirical or design work.

### 6.1. Ontologies supporting problem framing

The first experiment will test the following proposition: "*Users provided with an application ontology are able to better frame problems than users without such support, independently of their domain knowledge*".

This experiment will ask subjects—senior students in a business program—to complete a task which consist of framing and describing a problem based on a case. Our independent variables will consist of two treatments (3 by 2 design). The first treatment will be whether subjects receive a domain ontology, in the form of (1) a written script, (2) a textual domain ontology, or (3) a visual domain ontology. The second treatment will include whether they receive a task ontology, as either: (1) a written script including a CATWOE presentation, (2) a textual application ontology, or (3) a visual application ontology. The dependent variable will be the quality of the resulting problem framing and description, assessed by experts.

### 6.2. Ontologies supporting information discovery

The second experiment will test the proposition: "*Users provided with an application ontology are able to identify information sources more efficiently and comprehensively than users without such support*".

This experiment will ask subjects—senior students in a business program—to complete a task consisting of identifying relevant information sources based on a case presenting and formulating a problem. The treatment will be whether subjects receive an ontology, being provided with one of the following supporting tools: a textual application ontology or a visual application ontology, both with relationships to related or unrelated information sources. The control group will be provided with a written script and a textual description of the information sources. The dependent variable will measure how comprehensive the information they discover is, and the rationale behind seeking this information.

### 6.3. Ontologies supporting information retrieval

This research question will investigate if: "*Users using an application ontology are able to retrieve more efficiently information from identified sources than users without such support*". Given that a user already knows what information to retrieve, can they efficiently retrieve this information with the help of an application ontology. In this experiment, we will study the case of the aggregation of multiple sources of information accessed through the ontology.

### 6.4. Ontologies supporting negotiation support systems

Finally, after the investigation of the three empirical questions, we will start the design of a negotiation support system using ontologies. In this study, we will use a design science research approach to validate our overall approach. The artifact studied will be used to build problem representations merging multiple ontologies and to support users in identifying multiple world views and preparing a negotiation or decision based on the resulting dissensions. The research will enable us to answer questions such as: "How do we present the ontology library in order to support users in choosing the right ontologies to cover the problem domain?", "How do we support the identification of dissensions based on the network of ontologies?" or "How do we select, retrieve and present the relevant information in order to efficiently support the users' informational needs?"

## 7. Conclusions

This paper introduces a novel approach to supporting users in framing problems and identifying information sources in domains that are increasingly complex and thus, less familiar to the users. To achieve this, we combine well-known methods and concepts in an innovative way in order to support users in the areas of (1) domain understanding, (2) problem formulation, (3) specification of issues and options, and (4) information identification prior to the use of traditional support systems. We showed that by using a

domain ontology and a task ontology based on SSM—more precisely, the CATWOE method to create root definitions—we should be able to support users in appropriately framing problems and identifying information sources as well as retrieving the identified information. These results are important because they will improve the outcome of computer support systems, assuming better problem framing and the use of relevant information. We conclude by presenting how we will explore these assumptions and the expected outcomes.

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